MANAGEMENT OF GRASSY BALDS IN GREAT SMOKY MOUNTAINS NATIONAL PARK

RESEARCH/RESOURCES MANAGEMENT REPORT No. 17

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SOUTHEAST REGION

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IN

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RESEARCH/RESOURCES MANAGEMENT REPORT NO. 17

1977

This report represents a reprinting of the final report
to the National Park Service on Contract Number CX 500061100.

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For there is hope of a tree
if it be cut down
that it will sprout again,
and that the tender branch thereof
will not cease,
Though the root thereof
wax old in the earth
and the stock thereof
die in the ground;
Yet through the scent of water
it will bud,
and bring forth boughs like a plant.

Job 14: 7-9

To Ken

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INTRODUCTION

The grassy balds of the Southern Appalachians are (or were) open meadows dominated by *Danthonia compressa* (mountain oat grass) and other grasses. They occur mostly on rounded peaks between 5000 feet and 6000 feet, and they have intrigued many botanists and ecologists because all the mountains in the region are several thousand feet below timberline. Therefore, the absence of trees from these bald spots was hard to explain. Since the balds were mentioned in Cherokee legends, they were considered to be very old and to have been produced by natural factors. Many theories were proposed to explain why trees were not growing on these areas and why they remained grassy (the reader is referred to Gersmehl (1970) for a summary of literature on grassy bald origin and perpetuation).

All balds are now being invaded by woody plants, although the process is very slow on some of them. Tree ring counts from increment cores and cut stumps and comparison of old photographs with present-day appearance of the balds suggest that woody plants began invading grassy balds in the Great Smoky Mountains when local people stopped grazing their livestock on them (Lindsay 1976, Lindsay in prep.). Therefore, it seems that regardless of what originally removed trees from these bald spots, grazing was responsible for maintaining their grassy condition. Similar sites from which trees were removed by logging and fire about 50 years ago have not become grassy unless they were grazed. This suggests that grazing is necessary to cause a cleared area to become covered with grass (Ramseur 1976, Lindsay in prep.).

The encroachment of trees onto the balds in the Smokies is causing the loss of many esthetic values. Visitors to Great Smoky Mountains National Park frequently visit these large high grassy spaces in the midst of dense forest. The views from the balds are being restricted by the growth of trees and their encroachment on and around the balds. Gregory Bald offers a world-famous natural display of hybrid azaleas in a wide range of colors. These azaleas are being shaded out by trees growing over them or crowded by blueberries growing around them. If Gregory Bald is not managed, these azaleas will eventually be smothered, and only a remnant of them will bloom. The balds have a historic and interpretive value. If one of them is preserved visitors will be able to see how early settlers influenced and used the mountaintops. Without disturbance to set back or at least retard the invasion of woody plants, the balds will lose their distinctive grassy aspect in 50 to 100 years (Ramseur 1976, Lindsay in prep.).

Shortly after Great Smoky Mountains National Park (to be referred to as GRSM) was established, many people noticed changes towards a woody plant community. The Great Smoky Mountains Conservation Association asked that Gregory Bald, Andrews Bald, and Spence Field be preserved as they were before the establishment of GRSM. Gregory and Andrew Balds have been tentatively designated as historical areas to be excluded from the proposed wilderness area that will include most of the park so that they may be managed to restore and maintain their original appearance.

Management was tested on small plots on Gregory Bald in the summers of 1975 and 1976. I also visited several sites being managed by the Forest Service and Shenandoah National Park and spoke to the people involved. This report presents my observations and gives recommendations for management.

DESCRIPTION OF THE SITES TO BE MANAGED

Gregory Bald is a rounded summit 4949 feet (1508 m) high on the Tennessee-North Carolina line on the main ridge of the Great Smoky Mountains. It lies about 8 km south of the west end of Cades Cove (Figure 1A). The top of the bald on the east end is almost level, but other parts of the bald slope steeply. The bald area extends slightly farther down hill on the south side than on the north side. The original area of the bald was about 16 acres.

The forest on the south edge of Gregory Bald is dominated by red oak (*Quercus rubra*) with occasional stems of other species. The more mesic forest on the north edge is a mixture of oak, yellow birch (*Betula lutea*), beech (*Fagus grandifolia*), and buckeye (*Aesculus octandra*). Serviceberry (*Amelanchier laevis*) and hawthorn (*Crataegus* sp.) occur beneath the canopy in both edges of the bald and are most aggressive invading woody species on the grassy part of the bald. Less than half of the area of the bald not yet covered by young forest is still grassy, most of it being covered with blueberries (*Vaccinium* spp.), serviceberry, hawthorn, and trees of species found in the surrounding forests. Rocks on and near the surface are common. Much of the bald has been disturbed by wild boar who roll back the turf while rooting for food.

Andrews Bald is on a relatively flat part of Forney Ridge about 2 km south of the Clingmans Dome parking lot (Figure 1B). The altitude is between 5560 feet and 5800 feet (1695 m and 1768 m). The ground drops precipitously on the south and east edges of the bald, but the rest of the bald and the surrounding area slope gently to the southwest. The original area was about 13 acres.

Spruce-fir (*Picea rubens-Abies fraseri*) forest grows on the west and north edges and hardwood forest, dominated by beech, grows on the south and

Figure 1A. Location of Gregory Bald (from USGS 7 1/2' series, Cades Cove quadrangle).

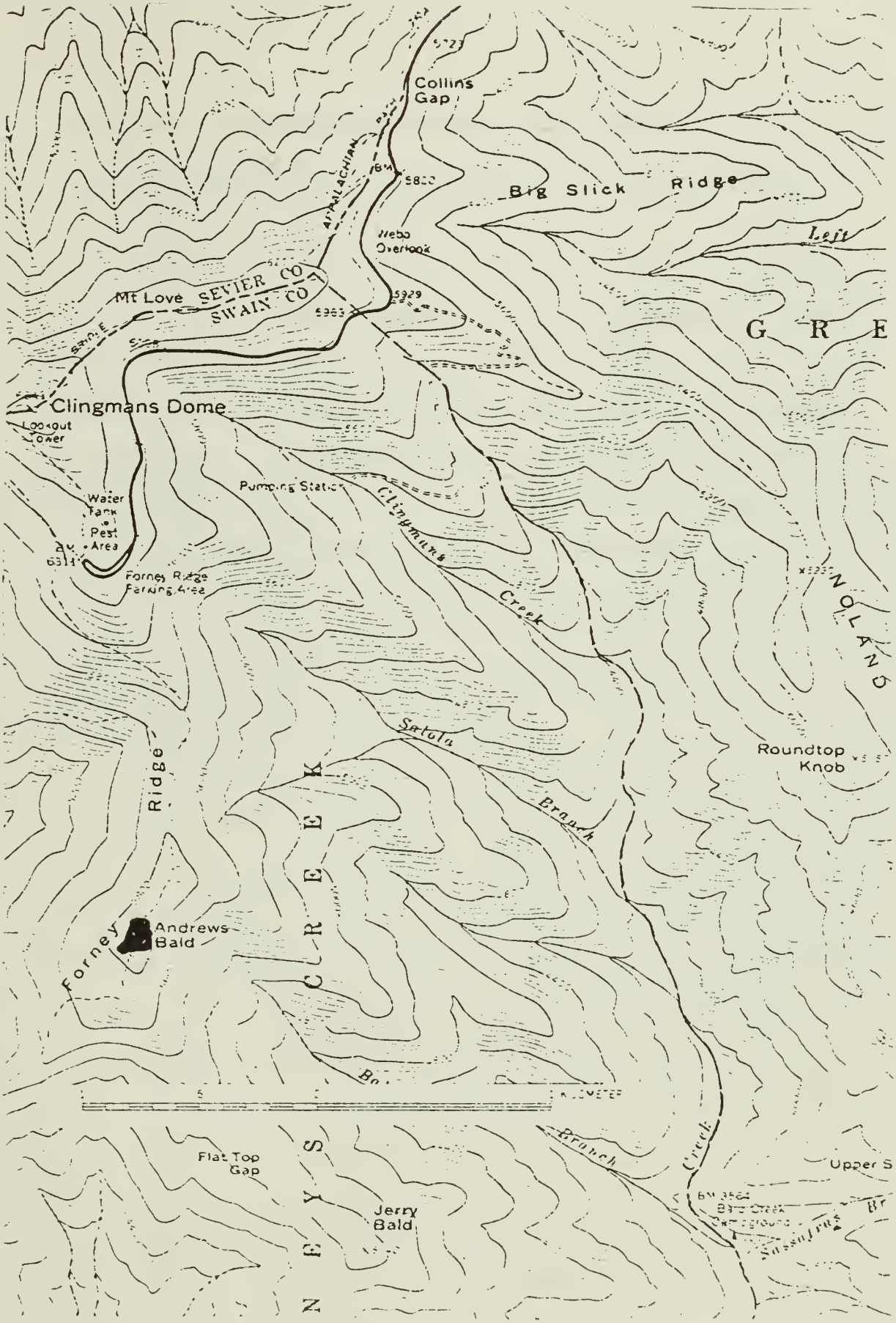

Figure 1B. Location of Andrews Bald (from USGS 7 1/2' series Clingmans Dome quadrangle).

east edges. Rhododendrons (*Rhododendron catawbiense*) are scattered over most of the bald and are especially concentrated near the south and east edges. Fir trees are becoming established on all parts of the bald, invading most actively around the edges. Hawthorn and serviceberry are common. A small bog is in the southwest corner of the bald.

The balsam wooly aphid is killing mature fir trees in the Clingmans Dome area, and in a few years this insect will probably spread to the vicinity of Andrews Bald. The death of mature fir trees may lead to a forest of fir saplings on the north and west edges of Andrews Bald or allow the hardwood forest to grow a little farther uphill. The exact effect on management cannot be predicted.

TESTS OF POSSIBLE METHODS OF BALD MANAGEMENT

I. EXPERIENCES OF OTHER AGENCIES MANAGING BALD-LIKE VEGETATION

In this section I shall describe how other agencies are managing similar vegetation and the effect, cost and other impacts of the methods used. My sources are: (1) Personal communications with Ben Sanders of National Forests in North Carolina; Charles Blankenship of Jefferson National Forest; Junius Beaver, District Ranger of Jefferson National Forest, Marion, Virginia; Basil Barr, District Ranger of Cherokee National Forest in Erwin, Tennessee; and W. Dean Cocking of Madison College in Harrisonburg, Virginia. (2) Unpublished reports by Forest Service staff and others (Byrne 1973, Jackson 1973, Komarek 1975, Zeedyk 1975, Sanders 1975, Anonymous) which are available in the GRSM library. (3) My personal observations of some of the sites.

The United States Forest Service is managing several grassy balds, heath balds, and other open grassy areas in the southern Appalachians. The policy of the Southern Region of the Forest Service is "to reestablish and maintain the character of these 'balds'. . . contingent on local determination in the unit planning process." The main objectives of their management program are to preserve scenic, ecological, and wildlife values (U.S.D.A. 1975). Shenandoah National Park is maintaining a large open grassy area, Big Meadows, for scenery and historical purposes.

Fire

Fire is probably being used more than any other technique. Areas being managed with fire include several hundred acres on the Pisgah National

Forest, North Carolina, some small heath balds on the Pisgah and Nantahala National Forests in North Carolina, and parts of Pine Mountain in the Mount Rogers crest zone in the Mount Rogers National Recreation Area. Fire is also being tested on very small plots on Big Meadows in Shenandoah National Park.

The area on the Pisgah National Forest is part of thousands of acres which originally supported mature spruce-fir forest. After the original forest was logged in the 1930's, fires swept through the slash and removed all tree cover. The area was subsequently grazed heavily by domestic livestock. The area now being managed is bounded on the north by the Shining Rock Wilderness Area and on the south by the Blue Ridge Parkway. It lies near Milepost 420 of the parkway. The vegetation of the highest, most exposed points is dominated by *Danthonia compressa*, *Phleum pratense*, and other grasses. These areas closely resemble "natural" grassy balds except for frequent old stumps. The less exposed slopes and valleys support various trees and shrub communities, including young spruce-fir forest; large and fairly open stands of fire cherry (*Prunus pensylvanica*); mixed hardwood forests with beech, fire cherry, serviceberry, and yellow birch; and shrubby areas with rhododendron, mountain laurel (*Kalmia latifolia*), and blueberries. Blackberries (*Rubus spp.*) are frequent under the cherry and mixed hardwood stands.

Different parts of this area have been burned in the spring or fall since 1973. In the winter of 1975, only about 30 acres had been burned more than once. Usually, 200 to 300 acres were burned at one time. The fires were set in late spring or early fall when suitable weather conditions occur in the southern Appalachians. Fires had

more effect in the fall because favorable weather conditions lasted longer and the fuel was less compacted.

The technique used in both spring and fall burns was to burn in perimeter lines by setting a line of fire with a drip torch and spraying the outer side with backpack pumps. After the perimeter was secure, interior fire lines were set. Roads and streams were often used as fire breaks, reducing the need to set perimeter fires. Eight to ten men were needed in the crew. The time elapsed from starting the backfiring line on the perimeter to securing all lines and checking the fire at the end was 6 or 7 hours for a 200-acre burn.

The fires burned about 70 percent of the treated areas. Unburned areas were most common on northerly aspects and in wet seepages.

The intensity of the burn also depended on cover type. Grass cover burned in a light surface fire; the cured grass cover burned, but very little of the surface detritus covering the soil burned. Dense patches of blackberry burned intensely because of the density of fuel, and the surface detritus was often burned off the soil, exposing it to erosion.

Between 30 and 70 percent of the woody plant cover was killed, depending on the species and the understory cover. The tops of nearly all the trees in stands of fire cherry with blackberry in the understory were killed, although many of the killed trees sprouted. Larger trees (> 15 cm. dbh.) on the Graveyard Ridge area, burned in the spring of 1973, seem to be almost unaffected by the fire. Fire killed the tops of rhododendron, mountain laurel, and blueberry, but most of these shrubs sprouted. Although the young sprouts seem to be preferred deer browse, the dead tops often

protected the sprouts from browsing. The grasses responded favorably to the burns, becoming thick and lush. Even when the fire had little effect on the large trees, it opened up the understory, leaving an orchard type forest. Forest Service personnel working in this area have concluded that these fires are about 75 percent effective in causing retrogression from a shrub to a herbaceous community at the edge of the belt of invading shrubs. In other places fire can only prevent further invasion rather than causing any noticeable retrogression.

The visual impact of the fires is most striking between the time of the burn and the subsequent regrowth of ground cover. After a spring burn this period is only a week or two long, since grass grows faster on burned than on unburned sites. On a site burned in the fall regrowth does not occur for 5 or 6 months. The ground is black, and in heavily burned patches bare soil is exposed. Since the dead tops of woody plants were not removed, their visual impact will persist for many years. They may become less noticeable as they fall over and the herbaceous cover grows up around them. A newly burned area has a strong smoky odor that can persist through several days of rain. Figure 2 shows the appearance of the Sam Knob area of the Pisgah National Forest about 2 months after it was burned.

Burning on the Mount Rogers Recreation Area seems to have had a similar impact. Smaller areas were treated, probably because of the Virginia law that prohibits burning before 4 p.m. The burned areas I saw were relatively level and had burned with a light surface fire that killed small shrubs.

National Forests in North Carolina has also conducted prescribed burns on some heath balds, including Burningtown Bald and Maple Camp Bald.

Figure 2. Burned area on Sam Knob, Pisgah National Forest, North Carolina in January 1976, about 2 months after burn.

Figure 3. Beauty Spot, Cherokee National Forest, Tennessee, a grassy area maintained by mowing. Photograph taken in November 1975.

Figure 4. Fence line between grazed and ungrazed areas on Pine Mountain, Mount Rogers National Recreation Area, Jefferson National Forest, Virginia. Notice the absence of blueberry and blackberry sprouts on the grazed side.

Fig. 2

Fig. 3

Shrub kill on these areas was high, ranging up to 100 percent in patches, but sprouting was prolific for most species. On Burningtown Bald 25 percent of the overstory oak trees were killed or severly damaged. Techniques were similar to those used on the grassy areas except that fire lines were hand raked rather than burned in, and on Burningtown Bald, converging "V-head" fires were set which resulted in a very hot fire where the two lines converged.

Dean Cocking of Madison College, Harrisonburg, Va., is experimenting with fire as an alternative method of managing Big Meadows in Shenandoah National Park which has been maintained by annual mowing. The burns have been confined to 100 m^2 plots ignited by flares. Cocking's tentative conclusion is that fire will be effective in retarding invasion by woody plants but cannot cause areas that have already developed a dense growth of shrubs to revert to grass.

Prescribed burns are estimated to cost between $10 and $15 an acre for large areas. They have been accepted by the public where they have been used. Spring burns are favored because the rapid regrowth of herbaceous vegetation reduces the loss of nutrients, prevents soil erosion, and lessens the visual impact. However, suitable weather for burning is three times as likely in the fall, and fuel is then drier and less compacted, resulting in a better burn.

Mowing

Mechanical mowing has been used on Beauty Spot on the Cherokee National Forest and Big Meadows in Shenandoah National Park. These areas are relatively level and traversed or bounded by maintained roads, making access by

a tractor quite easy. On Beauty Spot, a high, exposed, and relatively dry site, mowing has maintained an attractive sward with very few shrub and tree sprouts (Figure 3). On Big Meadows, which is less exposed and wetter, blueberries and black locust seedlings are very common, although the mowing keeps them low. The cost is estimated to be from $40 to $75 per acre. The steepness, rockiness, and inaccessibility of Gregory and Andrews balds make them completely unsuited for this type of management.

Grazing

The Forest Service has tested grazing only on Pine Mountain on the Mount Rogers Natural Resource Area in Jefferson National Forest. This area is very similar to the area near Shining Rock on Pisgah National Forest in its topography, vegetation, and history. The original spruce-fir forest was removed by logging and fires in the early twentieth century, leaving a large open grassy area of several thousand acres. This area has subsequently been grazed and occasionally burned. Parts of the area are being invaded by spruce, mountain laurel, beech, and blueberries. Hawthorn is present in patches.

Since the area is large, gently sloping with many springs on it, it has been feasible to construct fences and divide it into several large grazing areas. Grazing has been tried to a limited extent. Young cattle have not gained weight fast enough for high profits to the grazier. Cattle have had significant impact on the vegetation but are not enough by themselves to control the woody plants.

A herd of ponies left on the area for several years has not only survived the winters but increased greatly. They probably have a slight impact on the woody vegetation.

Sheep were tried one year, but no definite evaluation could be made of their effectiveness because of several mishaps. They had to be moved from the pasture where they were being held at lower elevations before the grass higher up was green. When they were driven to the top, the only green vegetation was mountain laurel, and many sheep died from eating it. This experience has made other sheep graziers somewhat reluctant to lease land for grazing. In addition, most of the sheep graziers come from farther west (Montana) and cannot appreciate the high productivity of the Mount Rogers area. Therefore they do not graze enough sheep to affect the woody plants significantly.

Although grazing has not yet been used as extensively as Jefferson National Forest staff would like, they still feel that it would be one of the cheapest methods since grazing fees will help pay for building the necessary fences. A new perimeter fence of wire is being put up, and construction of rail fences to subdivide the area into individual grazing ranges has begun. No public complaints about grazing stock or fences have been noted except that a few hikers have complained of being intimidated by pony stallions.

Other potential problems about which Jefferson National Forest staff are concerned are *Eupatorium* poisoning in the fall, erosion caused by dense stocking of livestock and lack of effects at low stocking densities. However, where grazed and ungrazed areas are separated by a fence, the differences in the abundance of blackberries and blueberries is apparent, so it seems that grazing will prevent the establishment of shrubs (Figure 4). Areas now being grazed have a dense cover of short grass and no noticeable erosion.

It is also interesting to note the effects of grazing on Hemphill Bald which is divided by the Great Smoky Mountains National Park boundary. On the park side of the boundary hawthorn, black locust, yellow birch, and buckeye trees have grown up and shaded the ground sufficiently to produce a typical forest understory. The side that is owned by Cataloochee Ranch has been kept open by cattle, which have maintained a short, dense sward (Figure 5). The few trees present show heavy browsing. Severe erosion has occurred on some of the steeper slopes.

Hand Cutting

Hand cutting has been tried on several small balds, Roan Mountain Gardens, and parts of the Mount Rogers Natural Resource Area. It has been found effective where tree species are encroaching on grass or heath balds, but it is not feasible for controlling invasion of grass by heath. It can be applied to almost any site, and for small scattered balds the difference in cost between this method and burning is not as high as it is on very large areas. Heavy sprouting of some species has been observed. Impacts can be controlled very precisely. The main drawback is the high cost--estimated to be about $100 per acre. Morever, this figure apparently does not include the labor cost of disposing of the slash, and most of the areas to which it has been applied are either accessible by jeeps or pickup trucks or closer to roads than Gregory or Andrews Balds.

Figure 5. Hemphill Bald on the Cataloochee Divide on the southeastern boundary of Great Smoky Mountains National Park. The area on the right of the boundary fence is still grazed by cattle from Cataloochee Ranch, and the forest on the far side of the fence has grown up since the establishment of the park.

II. TRAILS OF POSSIBLE TECHNIQUES ON GREGORY BALD, 1975-1976

In the summers of 1975 and 1976 various methods of clearing and maintenance were tested on Gregory Bald in Great Smoky Mountains National Park. Gregory Bald was chosen as the test area because the predominance of hardwood species presented a more severe test of possible techniques, places to establish a camp were closer, and shrub invasion is more rapid.

Work in 1975 was confined to clearing small patches of hawthorn, selectively cutting larger plots when the visual impact of complete clearing was judged to be too great, removing isolated trees, and clipping blueberry patches. The areas affected are shown in Figure 6. Since the work was done in August and October, no evaluation of methods of controlling sprouts was attempted.

Twelve plots were cleared in June and July of 1976. Six 20 x 25 m^2 plots were on the open bald and included all the cover types present except for extremely dense hawthorn scrub. All trees and visible seedlings were cut down, and on some plots blueberries were cut and burned. The other six plots were belts 25 m wide extending from near the original edge of the bald to the present edge. Three of them were in the dry oak forest on the south side and other three in the more mesic oak-beech-birch forest on the north side. The areas of these plots ranged from 780 m^2 to 1050 m^2. On half of each strip, all trees less than 10 cm d.b.h. were removed; on the other half all trees less than 20 cm d.b.h. were removed. In addition about 0.4 ha. was cleared and enclosed by an electric fence to test the effects of grazing animals. Several smaller plots were fenced off

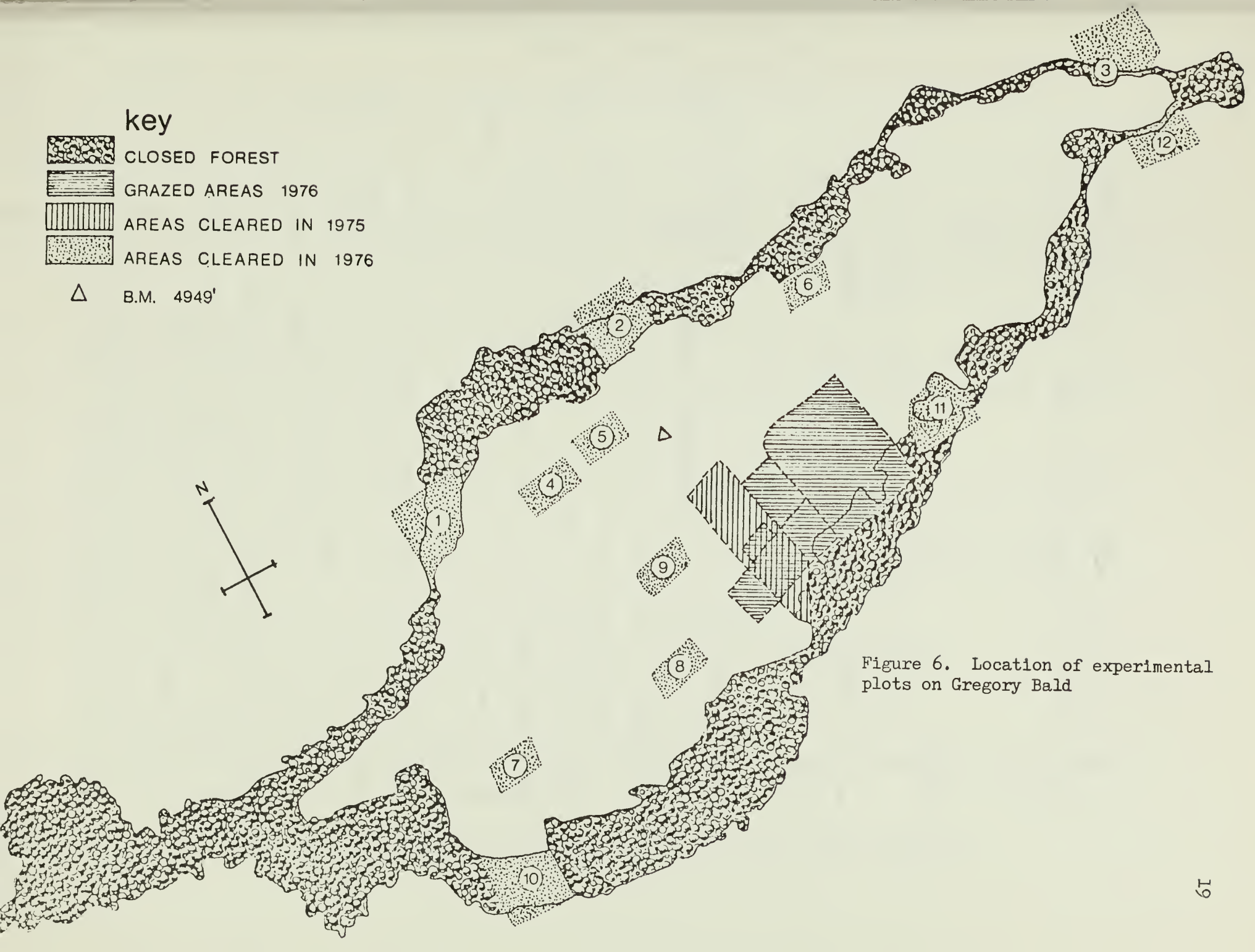

Figure 6. Location of experimental plots on Gregory Bald

for grazing as circumstances required. All plots cleared in 1976 are shown in Figure 1. The plots have been marked with steel stakes at each corner.

Clearing

Thousands of trees that have grown on and around Gregory and Andrews balds must be removed to restore the 1935 appearance of these balds. Since many of these trees are too big to be killed by fire some cutting is probably necessary. In clearing the plots on Gregory Bald, I attempted to compare the effects, cost, visual and aural impact, and difficulty of various methods and tools. Data about the clearing of selected plots are summarized in Table 1.

Only hand tools were used to clear the six plots on the bald. The number of trees on each of these 500 m^2 plots ranged from 6 to 29, and the time required to cut down all trees ranged from one to five man-hours. The time was influenced by the amount of shrubbery in the way, the number of trees, the size of trees, and the species of any large trees. Large (basal diameter > 20 cm) individuals of species with hard wood such as serviceberry or black cherry (*Prunus serotina*) required a disproportionate amount of time to cut; sometimes half the time required to clear a plot would be spent on one of these trees. In such cases, using a chain saw would have greatly decreased the amount of time needed, perhaps by as much as one-half. The average amount of time to fell trees on each of the six plots on the bald was about 2 3/4 man-hours. The density of trees on these plots was probably slightly less than average for areas on the bald that have trees but about average for the bald as a whole if one considers the few

TABLE 1

SELECTED DATA ON PLOTS CLEARED IN THE SUMMER OF 1976

Plot	Area (m^2)	Date Cleared	No. of Trees Cut <12 cm dbh	No. of Trees Cut ≥12 cm dbh	Time to Cut (man-hours)	Time to Remove Slash (man-hours)	Comments
1	1055	-	264	5	24	-	Chain saw used on about half of trees
2	721	July 8-9	198	6	16	-	
3	875	June 23	123	25	10	30	Very little underbrush
4	500	June 22	15	0	1	8	About 25 seedlings and sprouts also cut
5	500	June 10	14	10	5	20	
6	500	June 22	14	15	1.5	10	
7	500	June 21	10	3	4	16	Stumps sawed off with chain saw August 12
9	500	June 22	15	4	3	6	Almost no shrubs. Not all slash carried away; some left for burning
10	771	June 30	-	-	-	-	
11	839	July 13-14	166	10	20*	60*	YCC assisted Stumps later sawed with chain saw
12	962	July 2-3	99	18	-	-	

- data not available * estimate

Plots 1-3 were in the forest on the north edge of the bald, plots 4-6 on the north side of the bald, plots 7-9 on the south side of the bald, and plots 10-12 on the woods on the south edge of the bald.

remaining grassy areas. Since the area of the open area of the bald as shown in Figure 6 is about 2.5 ha, equivalent to about 50 of these plots, it would take about 150 man-hours to just cut down the trees on the bald with hand tools, not counting time needed to sharpen axes and so forth.

The most time-consuming part of clearing was cutting the felled trees in pieces small enough to be dragged and dragging them into the woods and far enough downhill that they would not be seen by the average visitor. This process took from two to eight times as long as cutting down the trees. The time depended on the species involved, the location of the plot, and the amount of shrubs on the plot and at the edge of the woods nearby. Hawthorns grow with a profusely branching habit and had to be cut up much more to be manageable than a relatively unbranched tree such as an oak. Trees from plots far from the edge of the bald had to be dragged farther than trees on plots near the edge. Dense shrub growth between the cleared plot and the area to which the slash was dragged slowed the work greatly. For reasons which I shall discuss more thoroughly, I feel this method of disposing of the slash will not be feasible when the whole bald is cleared.

Blueberries, blackberries and other unwanted shrubs were cleared from some of these plots (No.'s 4,5,6, and 7) by Youth Conservation Corps, (YCC) crews. The crew members used brush cutters while the leader used a scythe. The cuttings were piled up with a pitchfork for burning. These tools left stubs of bushes 10 to 20 cm high. Some of the thicker stems had to be cut individually with pruners. A YCC crew could clear shrubs from four or five of these plots in a day. The piled-up clippings burned very readily after being allowed to dry for a few days.

Blueberries on the burned patches sprouted much less, but the sprouts grew faster than sprouts on unburned plots. Seedlings of *Danthonia* and *Potentilla* started growing on burned areas within a week.

The plots in the forest around the bald were cleared both with hand tools and chain saws. Lack of experience and mechanical difficulties with the chain saws prevented an accurate estimation of the amount of time that could have been saved by using them. Plot 1 took about 24 man-hours to clear with two axes and one chain saw. This plot was the largest cleared and had a dense growth of hawthorn at the edge of the bald. Plot 2 was cleared in 16 man-hours, by two persons using axes. Plot 3 was cleared in 10 man-hours with hand tools. As with the plots on the bald (4-9), removing the slash took much longer than felling the trees. The relative lack of underbrush in the forest on the north side of the bald made this job easier than it was on the bald or in the woods on the south side.

Plots 10, 11, and 12, on the south side of the bald, were cleared with the help of YCC crews. An eight-man YCC crew and three or four members of the research team took a day to a day-and-a-half to clear each of these plots and remove the slash. The denser growth of underbrush, mainly blackberries and blueberries, on the south side hindered the removal of slash greatly until paths were cut through it.

A total of 0.6 ha was cleared in the forest. This represents about 1/12 of the amount of forest that needs to be cleared. The total time required to fell all the forest that has grown up around the edge of the bald would be between 120 and 300 man-hours. The amount of time to dispose of the slash without burning could be as much as 3,000 man-hours because the amount of time needed increases disproportionately with the amount of slash. One just cannot find a convientent place to put it.

The usefulness of YCC labor varies considerably with the individual crew. One of the two crews helping us accomplished much more than the other. YCC crew members were most proficient at jobs such as cutting blueberries or dragging brush. Most of them were not very skillful in using axes and left rather high stumps. However, the axes given the crews were too heavy for high school age workers, four or five pounds, and not sharp. They could probably have done better work with more suitable tools. YCC workers would probably be most useful for tasks like cutting up felled trees and piling them up to be burned, or cutting shrubs.

Hauling slash through the forest to get it out of sight caused noticeable damage to the understory. Herbs were flattened, crushed, and uprooted. In places the surface litter was removed, increasing the likelihood of erosion. However, there was not enough room for all the slash that would be created in clearing the whole bald. Disposing of all slash in the forest would create a wall of brush tens of meters wide and one or two meters high that would take many years to decay and be a fire hazard for that time.

There was no significant difference in the time required to cut trees between 10 and 20 cm d.b.h. or to leave them. These trees were only about 10 percent of the stems on any plot. The light shade and protection from direct impact of precipitation might affect the regeneration of the understory, but effects cannot be evaluated until the summer of 1977. The appearance of the areas with these few larger trees left standing is reminiscent of the 1935 park-like forest around the bald.

The usefulness of chain saws was hard to evaluate because of mechanical trouble. The remoteness of the site renders maintenance and repair of power

equipment rather difficult, so breakdowns may be hard to avoid. The noise of the saws carried about half a mile and was uncomfortably loud only within a few feet of the saw. Although some hikers expressed surprise that we were not using power tools as they walked by Plot 3, many visitors would probably object to even a faint noise of machinery and such noise would be inconsistent with the character of the surrounding wilderness area. Chain saws definitely made it easier to cut very large trees, and it was easier to leave a low stump when a chain saw was used. Chain saws also saved time in cutting large, low-branching hawthorn trees because the spreading thorny branches which prevented a close approach to the tree could be sawed off quickly. Since a person using a chain saw does not have to trample around a tree as much as someone using an axe, damage to the understory was reduced. The low, flat-topped stumps were not as noticeable as the higher, uneven stumps left by axes. Hand saws were easy to use in felling trees that grew on steep slopes or had a noticeable lean. Trees not fitting this description were difficult to cut close to the ground. Since cutting down many trees and shrubs should only have to be done once, the cost will not be important after the first year.

Sprouts and Their Control

All woody species growing on the balds except for conifers (pines, spruce-fir, and hemlock) will sprout after they are cut down or otherwise killed unless a herbicide is used. Since the use of herbicides is probably incompatible with the wilderness character of the park and in conflict with its role as a Biosphere Reserve, other methods will have to be used to kill the stumps. If the sprouts are allowed to grow, the balds will appear shrubbier than if the trees had not been cut, because trees starting from stump and

root sprouts tend to have many stems. Therefore, it will be necessary to keep killing the sprouts by other methods until the roots and stump run out of reserves to grow any more and the tree, therefore, dies completely. Several years of constant treatment will probably be needed to kill the trees.

Three methods of controlling sprouts besides grazing were originally proposed: handcutting, spraying with salt to encourage native browsers, and herbicides. The use of herbicides was ruled out, and no trees grew enough sprouts in 1976 to justify hand cutting. Spraying with salt was abandoned because rain would often wash off salt hours after it was sprayed, spraying took as long as cutting by hand and deer and rabbits ate sprouts of most species without salt.

Very few sprouts developed on trees cut in the summer of 1976, perhaps because the trees were cut late in the summer and there was very little rain. The conclusions in this section are based on unsystematic observations made in 1976 of sprouts of trees cut in the fall of 1975 and a cursory inspection in April 1977 of plots cleared in 1976.

Most trees cut in 1976 grew no sprouts more than 5 cm long and did not grow more than one or two per tree before the end of August 1976. A notable exception was a beech tree on Plot 3 whose stump was chopped out of the ground by YCC workers. Although the stump could not sprout, dozens of sprouts came up along the roots. These sprouts were not touched by browsers. Even the goats used in the grazing experiments did not seem to be interested in them, however, the severe winter of 1976-1977 killed them.

Of the trees cut in 1975, the oaks sprouted most vigorously. Some of them had up to 20 sprouts about 1m high with several branches in one season's growth. Severe browsing by deer could not keep these sprouts in check. Cherries and serviceberry grew up to 10 sprouts per stump, usually unbranched and less than 0.5 m high. These were often browsed by deer or rabbits. Very few yellow birch trees were cut in 1975, but all birch stumps sprouted. Hawthorn trees whose sprouts were protected from browsing by slash left on them grew five to ten sprouts about 0.3 m high on each stump. Stumps not similarly protected produced only a few stubby sprouts with few leaves on them. These sprouts were not browsed, but they grew very slowly. Blueberry sprouts came thickly on patches that had been cleared completely by clipping off at ground level. These sprouts looked tender, but they were untouched by browsers. Sourwood (*Oxydendrum arboreum*) stumps grew vigorous sprouts that were much browsed. Maple (*Acer rubrum* and *A. pensylvanicum*) stumps sprouted moderately, but the sprouts were hardly browsed at all.

In the spring of 1977, nearly all the trees cut in 1976 had sprouts or buds. Although all oak sprouts that grew in the fall of 1976 were killed by the hard winter or browsed by deer, nearly every stump had dozens of buds ready to grow. When I inspected all the cleared plots, I found only three oak stumps that had no live buds. Cherry and serviceberry stumps cut extremely close to the ground and then exposed to the heat of burning blueberry clippings were still able to sprout although they had fewer sprouts than unburned stumps. Blueberries sprouted more on burned areas than on unburned areas, so frequent cutting throughout the growing season for several years may be the only way to control them.

Some stumps had their cambial layer chopped off by YCC workers. This procedure reduced the number of sprouts, but would not be worth the time it took unless it was done thoroughly. Only when the bark was chopped off all around the tree and well below ground level was sprouting completely arrested. Even a single sprout can grow into a new tree, and one sprout on a tree is as hard to find and cut as several.

Some stumps were chopped right out of the ground. Birch and oak trees were effectively killed, but beech and hawthorn sprouted prolifically from their roots, producing widely scattered shoots instead of a single clump that could be cut quickly.

Species seemed to be the only important factor in determining how much cut trees sprouted. Age and location made very little difference. Of common species, oaks grew the most sprouts, and had the fastest-growing sprouts. An oak stump from which sprouts have been removed for 2 years is still sprouting. Therefore, it will take many years to kill oaks. Hawthorn sprouts grow much more slowly, but they are not browsed and seem more tolerant of winter weather. Cherry, maple, birch, and serviceberry sprout moderately and are browsed lightly. Beech stumps produced many slow-growing root sprouts.

Many years of frequent hand cutting or grazing by goats or other animals which prefer woody browse will be necessary to bring sprouts under control without herbicides.

Regeneration On Cleared Plots

A complete study of regeneration on cleared plots will have to wait until the summer of 1977, but several trends are already evident. Patches of bare soil left on the bald where trees were cut down have been covered by

Rumex acetosella within a few days. *Potentilla canadensis* is also a frequent invader of these bare spots. When an area in the forest is cleared, *Dennstaedtia punctiloba* (hay-scented fern) and *Thelypteris noveboracensis* (New York fern) invade and cover the ground in a thick carpet. Where *Rubus* was present it grows back. *Danthonia compressa* and *Potentilla* also invade cleared areas in the forest. Where the forest floor is covered with sedges as in Plot 3, they recover quickly from the disturbance and form a pleasant grass-like cover. The areas where brush was burned are invaded by seedlings of *Potentilla* and grasses. Trampling by livestock retarded growth of ground cover where the forest had been cut back in the grazing enclosure. The effect of grazing on the herbaceous vegetation of the grazed areas cannot be measured until the summer of 1977. One striking change apparent in October 1976 was an increase in the amount of dwarf willow (*Salix humilis*).

Grazing *

Methods

Since grazing animals were the historical factor that maintained grassy balds, grazing by domestic stock was tried out on a small scale from July 14 to August 14, 1976 to compare the effects of different types of animals, to test the feasibility of using them on a large scale, and to evaluate the effectiveness of grazers as a method of sprout control.

The animals used were two 18-month-old Holstein heifers; four 6-month-old lambs, the product of a Hampshire-Suffolk cross; one 6-month-old and one 13-month old goat, both mixed Toggenberg-Saanen breed; two

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* I thank David Eissenstat for gathering and analyzing the data presented in this section.

18-month-old ewes; one 10-year-old donkey; and one 4-month-old donkey. The Holsteins and the ewes had been grass-fed before the study. The lambs had been raised for show by 4-H Club members in Sevier County and had previously been fed on grain. The goats had been fed a mixture of grain and hay, and the older goat was giving 3 or 4 quarts of milk a day. The donkeys had been on pasture before the study. To eliminate the possibility that escaped animals might start feral populations in the park, only females were used.

All animals, except the older donkey, were gathered in a pen in Cades Cove a few days before being taken up to Gregory Bald. They were examined and wormed by a veterinarian to reduce the possibility of their transmitting parasites to native animals. They were loaded into a pickup truck and a horse trailer and taken to the Parson Branch Road at about 7:00 a.m. Barring mechanical difficulties and other exceptional circumstances, visitor use of the road would be unaffected by moving cattle along it to Sams Gap so early in the morning. Since the cows could be led on halters and the rest of the animals followed them, few problems were encountered taking them up to Hannah Mountain Trail. Trail damage can be minimized by moving stock when the trail is dry.

A pen enclosing about 0.4 ha had been prepared in the location shown in Figure 6. A batter-operated electric fence supported by Fiberglas posts and trees had been erected. The erection of the fence took about 8 man-days including the time to clip shrubs along the fence line so that they would not ground out the fence. The bat-

tery was supposedly capable of charging a mile of wire for 6 months, so there would be no difficulty in charging a two-strand fence all around the bald. However, a rail fence built from the trees cut down on the bald would probably be more suitable for a back-country area.

After they had been on the bald for 2 days, all animals were measure for girth, height, and length. Girth was taken at the largest point of the midsection, called "barrel girth." Length was measured from the base of the tail to the base of the neck. Height was measured from the ground to the top of the shoulder blade.

Since the one large pen did not allow us to study the effect of each kind of animal individually and since the different kinds of animals often bothered each other, individual pens were fenced with electric wire and one kind of animal placed inside.

The two Holsteins were moved to a 200 m^2 pen on July 18. They were kept here until they began to show serious loss of weight because they ate all the grass and would not eat much of the remaining vegetation. After being allowed to regain their lost weight in the 0.4 ha pen, they were placed in a 400 m^2 enclosure until they began to act hungry. They were then tethered in some large patches of timothy (*Phleum pratense*) for two days, at which time the study was ended.

The six sheep were similarly grazed in a 200 m^2 pen until they lost weight. They were then moved to another 200 m^2 pen chosen for the presence of a large number (100) of hawthorn sprouts. The sheep were kept there for just 48 hours to determine their preference for hawthorn sprouts. They were then moved to a 400 m^2 pen with many oak sprouts for another 48 hours.

The donkeys were confined in a 100 m^2 pen to see if they would increase their preference for browsing woody plants if grass was limited. After 8 days it was necessary to move them back to the large enclosure because they were losing weight.

The goats were penned in a 100 m^2 corral made of poles lashed together with binder's twine because they did not seem to respond to the electric fence (they would but they managed not to touch the wire until after a separate pen had been built for them). After 10 days, they had exhausted all the palatable woody browse in the pen and started to squeeze out between the poles, even though much grass was left in the pen. They were then allowed to follow the researchers around all day. The older goat was milked twice a day, and both were given about a cup of sweet horse feed at milking time.

Water was provided for the sheep and goats from a supply carried up from Moore Spring, about 1 km from the grazed area. The older donkey could carry about 30 liters of water at one time, and this much water every other day was sufficient to support these animals. The water was poured into plastic basins placed in the pens and consumption measured daily. The amount of water in a control basin in an empty pen was also measured to account for precipitation and evaporation. The cows were haltered and led down near Moore Spring once or twice a day. Basins filled from the spring were brought to them to avoid contamination of the water. The donkeys were led to Moore Spring once a day.

Each of the small pens was mapped. The maps showed the locations of major concentrations of each important species and the degree to which it had been grazed or browsed. Browsing of woody species was assigned to

one of four classes: (1) 0-22%, (2) 2-50%, (3) 50-75%, and (4) 75-100%. the uneven division of classes 1 and 2 was chosen because of the large difference between sampling and actually inhibiting a plant. A similar index was used by Caslick (1974) to describe vegetation for wildlife management. All herbs were considered as one species. Most of the herb cover was *Danthonia compressa*. The amount of grazing was estimated by height classes: (1) 5 cm, (2) 2-4.9 cm. (3) 1-1.9 cm. (4) 0-0.9 cm. These classes correspond roughly to the classes of the same number for woody species. Photographs were taken of all plots.

Results

TABLE 2

Changes in Girth Measurement of Animals Grazed on Gregory Bald
July 14 to August 14, 1976

Animal	Girth Before (cm)	Girth After (cm)	% Change
Cow 1	190	198	4.2
Cow 2	196	208	6.1
Lamb 1	90	84	-6.6
Lamb 2	89	89	0.0
Lamb 3	87	89	2.3
Lamb 4	92	86	-6.5
Sheep 1	111	114	2.7
Sheep 2	100	117	17
Average	-	-	2.4±7.5*

* (Standard Deviation)

As can be seen in Table 2, no great loss of weight as determined by girth measurements occurred. Although some animals became thin at times, they recovered quickly when moved to where food was available. Since the four lambs were not full-grown, their failure to grow is significant and suggests that conditions were not ideal for them.

The animals' water consumption was measured for 13 days. The amounts varied considerably depending on the amount of dew, the temperature, and wind speed. Evaporation from the basins, which had a surface area of about .75 m^2, never exceeded 350 ml a day. On rainy days, the sheep, goats, and donkeys drank less than 250 ml. Cows drank more when they were watered twice a day than when they were watered once, but not significantly. Water consumption figures are summarized in Table 3. These results are affected by the unusual dryness of the weather. Rain fell only twice for short periods during the study.

TABLE 3

Water Consumption of Animals Grazed on Gregory Bald
July 14, to August 14, 1976

Animal	Average Daily Water Consumption (liters)	Range
Cow watered once daily	20.8	10.4 - 23.6
Cow watered twice daily	21.8	17.0 - 30.3
Goat	0.87	0.0 - 3.4
Sheep	0.53	0.23- 0.95
Donkey	2.2	0.0 - 3.56

Results of the daily checking of the extent to which each species was browsed are shown in Figure 7. The goats ate mainly oaks, hawthorn, and blueberries, in that order and only grazed the grass lightly. Sheep showed equal preference for blueberry sprouts, hawthorns, and oak. When confined in one pen too long, they bared the ground where grass grew. The cattle ate almost nothing but grass and oaks. They did not take hawthorn or blueberry until the grass was very short. Donkeys ate the grass extremely close to the ground when they were confined. They would occasionally browse oak and hawthorn, but they would not touch blueberries.

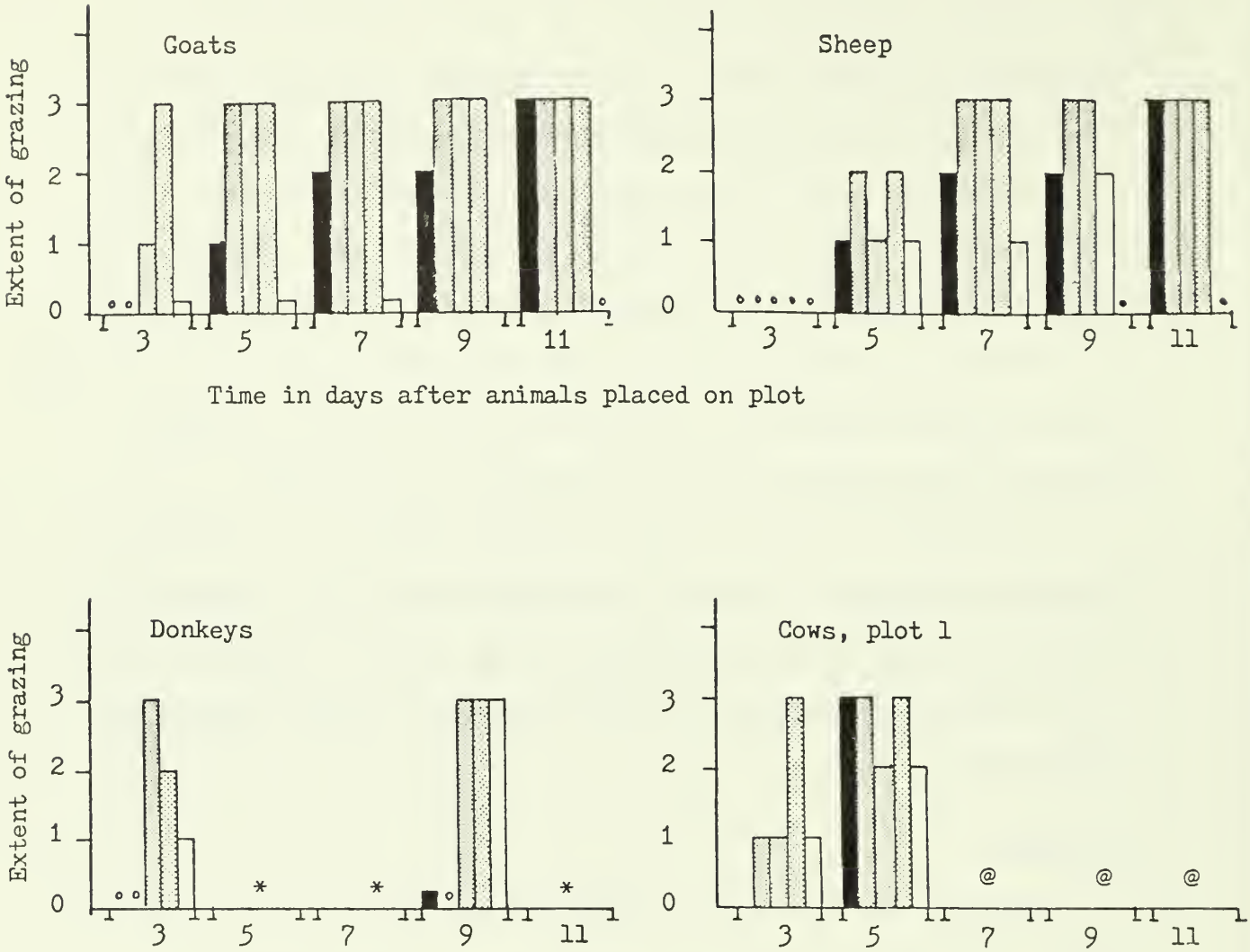
In the pen constructed to measure sheep's preference for hawthorn in the presence of grass, nearly all the apical buds and all the leaves were eaten, giving these a class (3) rating for the effect of browsing. In the similar pen with oak sprouts, a class (1) rating would best describe the oak sprouts.

Discussion

Conditions on the bald seemed favorable for maintaining the health of animals grazed there, but not for rapid growth of young animals. All animals seemed to find the weather conditions comfortable; only the sheep spent any significant amount of time seeking shade. The weight loss that occurred on some animals might not have occurred if they had not been confined in small pens.

With the exception of the cattle, providing the animals with water was not difficult. The sheep, goats, and donkeys needed water only two times a week even with no rain. Wind seemed to affect water consumption more than temperature. Leading the cattle to water every day was the most tedious procedure of the entire grazing study. The only closer springs are on steep

Figure 7. Effects of grazing animals on selected plants, Gregory BAld , 1976



slopes where the wild boar have already removed much of the ground cover, and watering cattle there would cause much erosion. The weather was unusually dry. Only two light rains occurred during the study period, but in the summer of 1975, thunderstorms occurred almost daily. In a year of normal rainfall, animals other than cattle would probably survive with no water other than what they got from dew and food. Stoddart *et al.* (1976) mention that sheep can survive a summer without water on the dry ranges of Montana if they have lush browse.

Goats are definitely the animal most suited to controlling brush. They preferred woody plants to grass and by standing on their hind legs would reach even higher than cattle. They are difficult to confine, however, and expensive to purchase in large numbers. Populations of any kind of feral livestock on the park would be a management problem, but goats could probably do more damage to vegetation than any other kind.

If about five goats per acre would be required for the first few years as suggested by National Academy of Sciences (1968), a herd of about 70 would be required to manage the entire original area of Gregory Bald. If the largest trees were cut down, goats could cause a real setback of succession and not just retard it because they prefer woody browse to grass and will eat the bark off small trees, thereby killing them.

Sheep were the next best browsers. They ate oak, hawthorn, and blueberry sprouts quite readily, but ate mature blueberries only when they had eaten the grass down to the ground. If the blueberries are cut first, sheep can probably keep them under control. The National Academy of Sciences (1968) recommends the same number of sheep as goats for brush control, so a flock of about 70 would probably suffice to manage the entire bald. Sheep

are even harder to buy in east Tennessee than goats and would be more likely to succumb to disease and predators. Sheep are the animals that maintained the bald before the park was established (Lindsay 1976), but they are more vulnerable to disease and predators.

Cattle ate much more than goats or sheep. They grazed down the grass faster than all other animals combined. They browsed frequently on oak and serviceberry, ripping off whole branches. They seldom ate hawthorn and would not touch blueberries even if they were exceedingly hungry. They were the only animals that liked to eat azaleas; the young shoots and flowers were among their preferred foods. The large amount of water they need would make a large herd of cattle extremely difficult to manage. Only by building a large and possibly unsightly catchment device could one provide enough water to keep cattle without leading them down to Moore Spring or Sheep Pen Gap every day.

Donkeys ate mostly grass but would eat hawthorn and oak when grass ran short. They would not set back succession but would be effective in retarding it. They were the easiest animals to manage and would probably fight off predators better than other animals. Donkeys are less likely to transmit diseases to the local deer population or get diseases because they are taxonomically less closely related. One cannot estimate from this study how many donkeys would be required to maintain the whole bald, but probably about one-half to one-third as many donkeys as sheep or goats would be needed.

The results of this study vary from what might have happened before the establishment of the park because animals were grazed for only 1 month instead of from May to September. Many species might have been more palatable in May and June, and animals would have affected different plant species.

Grazing would undoubtedly be effective in setting back succession and maintaining the balds. Since the historical method was grazing and since grazing has specific effects in trampling, selective removal of plants, and fertilization, grazing would lead to a species composition most like that before the establishment of the park. Grazing by animals other than cattle would discriminate in favor of azaleas on Gregory Bald as could no other method short of cutting every other kind of woody plant by hand. On the negative side, grazing would require a large initial investment of time and money for building fences and otherwise preparing the sites. Photographs of balds taken while they were still being grazed show very short grass and many bare, rocky patches (Figure 10). The part of Hemphill Bald outside the park looks similar (Figure 5, p. 17). The small size and remote location of Gregory and Andrews balds make it unlikely that any farmer would want to graze his stock there, so the park would probably have to buy the animals or pay a large fee to someone who consented to take his stock up there. The amount of money that would have to be invested in animals would approximate $12,000 for both balds. Great care would have to be taken to ensure that no animals escaped and established feral populations in the park. Animals might be lost to predators such as bears or panthers. Artiodactyles such as sheep, goats, or cattle would be likely to get

diseases from the native deer population or transmit diseases to them. While grazing would probably be the most effective method in the long run, it also has the most problems associated with it.

RECOMMENDATIONS FOR MANAGEMENT

I. THE CONDITION TO WHICH GREGORY AND ANDREWS BALDS SHOULD BE RESTORED

Ample evidence exists in the form of maps and photographs to show how Gregory and Andrews balds looked when the park was established. Maps based on recent aerial photography can be superimposed on the maps made by A. E. Bye in 1937 and 1944, which are now in the park archives, to show how much of the forest now surrounding the balds has grown since the original maps were made (Figures 8 and 9). Carlos Campbell has donated many of his photographs, some of which are reproduced in this report, and many other photographs are in the Park archives. Certainly "sufficient data exist to permit accurate restoration," as Park Service policy for historical areas requires (U.S.D.I. 1975).

Old photographs of Gregory Bald show a cover of short grass while grazing was still practiced (Figure 10). Bare ground and rocky patches were frequent. A few clumps of heavily browsed blueberries and dwarf willow grew near the edges. Camp (1931) mentions a fringe of unidentifiable heavily browsed shrubs around the edges. The forest did not come nearly as far up the slopes; Cades Cove was clearly visible from the east end of the bald (Figure 11), but it cannot be seen at all today. The forest around the bald consisted of large, widely spaced trees with grass underneath them (Figure 12). This open forest has now been filled in with many smaller trees, and the ground is too shaded to allow grass to grow.

The area mapped as bald in Bye's map of 1944 had only a few pines growing on it. Since grazing ceased 10 years before the map was made,

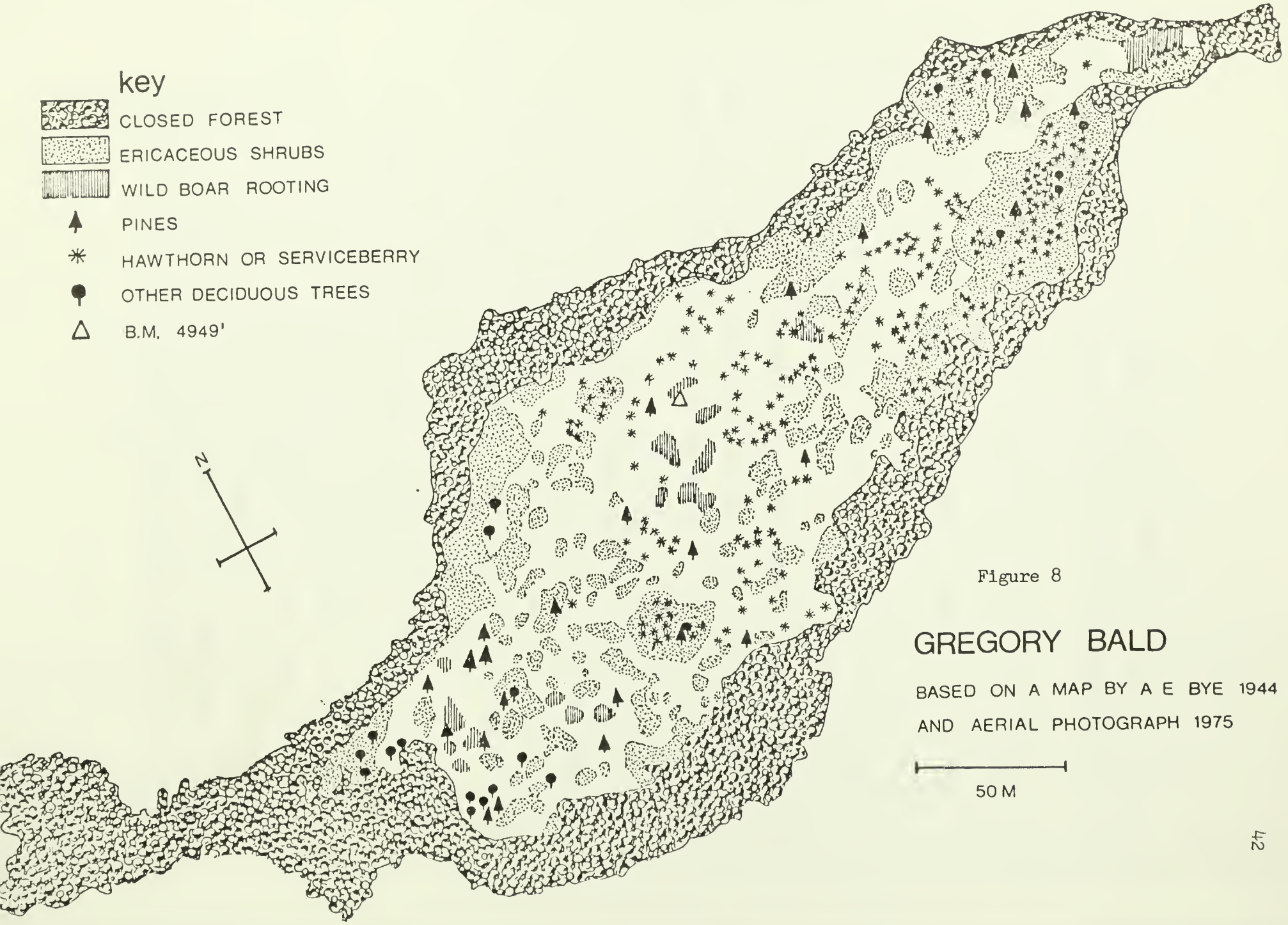


Figure 8

GREGORY BALD

BASED ON A MAP BY A E BYE 1944
AND AERIAL PHOTOGRAPH 1975

Figure 9. Map of Andrews Bald, Great Smoky Mountains National Park. Area mapped is the entire area that was grass in 1938.

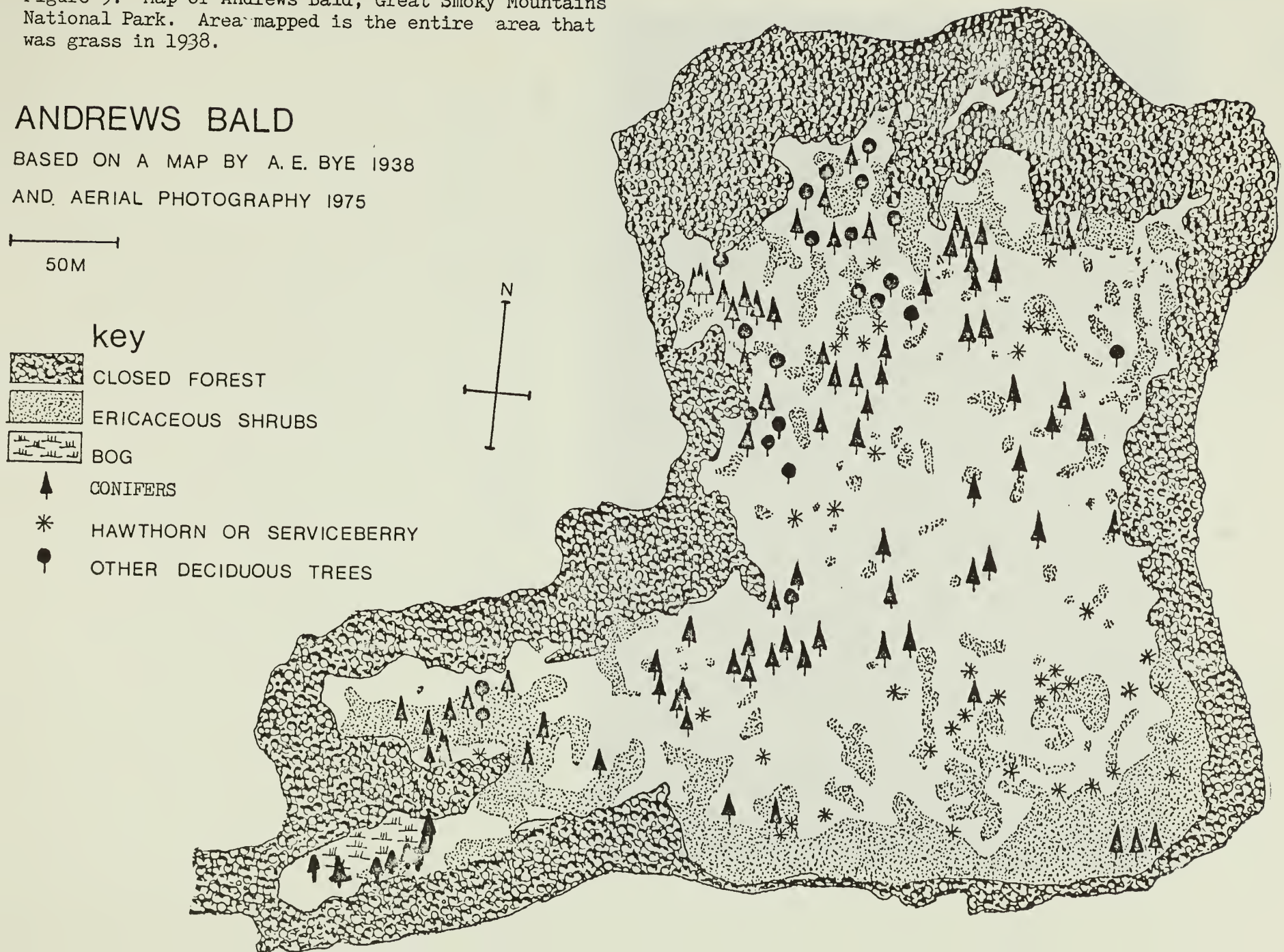


Figure 10. Sheep on Gregory Bald in 1921. Note the short grass and protruding rocks. (Photograph by Paul Adams)

Figure 11. View of Cades Cove from Gregory Bald in 1934. This view is now completely obscured by trees that have grown up since then. (Photograph by Carlos C. Campbell)

Figure 12. Woods at the edge of Gregory Bald in 1934. "Before grazing was stopped in 1934, the edges of Gregory Bald were 'open' forest, with no underbrush. For many years the sprouting oaks and beech were nipped off during their first year by grazing cattle and sheep. This open, city-park like forest existed along the main crest all the way from Gregory Bald to Thunderhead." (Photograph and text of caption by Carlos C. Campbell)

these trees were probably not present when the park was established, and the bald was entirely treeless. The azaleas for which Gregory Bald is famous were probably down on the lower slopes rather than on top, for Campbell's pictures show no large shrubs right on top of the bald (Figure 13). Bert Garner (quoted in Callahan 1975) wrote in 1958, "The azaleas cover more of the Bald every year . . . ." However, many azalea plants with variously colored flowers were certainly present before grazing ceased. Campbell noted that Harlan Kelsey, a member of Work's committee to survey possible sites for a national park in the east and a noted horticulturist, considered that the azaleas on Gregory Bald constituted one of the finest natural collections of azalea hybrids in the world in 1935 (letter 1976 and cited in Lindsay 1976). A letter in the park library (Eakin 1949) tells that the azalea display was impressive even in 1899. The azaleas that were present before the cessation of grazing are probably now smothered by the forest that has grown up especially rapidly on the south and west sides of the bald where they were most abundant (Shields quoted in Lindsay 1976). While azalea plants are still abundant where the forest has grown over them, these plants do not flower as vigorously as those in the open, and they are almost impossible to reach or see because of the dense growth of high blueberries surrounding them.

According to National Park Service management policies, "Trees, other vegetation, and other natural features in a historic zone are historic resources and shall be managed to reflect the general visual impact prevailing during the historic period" (U.S.D.I. 1975). A historically accurate restoration of Gregory Bald to 1935 would require the removal of all

Figure 13. View to the east from the top of Gregory Bald in 1934. Note the absence of trees and shrubs. (Photograph by Carlos C. Campbell)

trees and shrubs other than azaleas within the area shown in Figure 8 and the restoration of a grass-dominated cover all over the bald. In the area outside that shown on the map, all trees that have grown in since 1935 would have to be removed and the original grassy understory restored to a distance of 50 m or so beyond the original edge of the bald, to a break in the slope. Thus, a person standing at the original edge of the bald would see only the type of forest shown in Figure 12. The removal of the azaleas that have grown up since 1935 might not be adviseable, because these plants are one of the main attractions of Gregory Bald. The original azaleas around the edges will probably not bloom well for several years after they have been exposed to view. These azaleas also represent a hybrid swarm confined to Gregory Bald and found nowhere else in the wild.

Andrews Bald was somewhat larger than it is now and covered entirely with dense grass. None of the *Angelica triquinata*, which now grows everywhere, was present, and any rhododendrons or other tall shrubs were far down on the south edge. The bog in the southwest corner was not surrounded by trees as it is now. A photograph taken in 1938, 7 years after the cessation of grazing (Figure 14) shows grass dominating the vegetation of the bald. A few small shrubs and what appear to be some canes of *Rubus* can be seen, but the large rhododendrons, spruce, fir, serviceberry, and hawthron that now cover much of the bald are absent.

Accurate restoration of Andrews Bald would, therefore, require cutting down the trees in the area shown in Figure 9 and removing all trees and shrubs from the part of the bald that is still grassy. Retaining some of the rhododendrons for their colorful blooms might be desirable. There is no definite evidence of the appearance of the forest around the edge of the

Figure 14. Andrews Bald in 1938. (Photograph by Carlos C. Campbell)

bald. An old photograph of Indian Gap suggests that there was probably a narrow belt of open forest with a grassy understory around the edge.

II. METHODS OF RESTORATION AND THEIR IMPACT

The first step in restoration is to cut down all the trees that have grown on the balds since the establishment of the park. Other methods such as fire could be employed to kill the smaller trees, but this will leave dead snags which were not present historically. This will take about 500 man-hours on Gregory Bald, not including time to get rid of the slash; a similar amount of time would be required on Andrews Bald. Using hand tools would take longer than using power tools and leave more conspicuous stumps. Chain saws used by experienced people would probably reduce the time required by about half, but would pollute the balds with noise, gasoline fumes, and oil. The time needed to cut trees was only a small part of the total time to clear the balds since disposing of the slash took so much longer. Therefore, the method used to fell trees will have relatively little effect on the total labor cost. However, after the large trees are cut down, it is always feasible to uproot small seedlings. Whether all the trees are felled at one time or in stages does not seem important, although cutting a little further back on the edge each year or slowly thinning out the forests around the edges of the balds would cause less noticeable esthetic impact. If clearing is done early in the spring, a ground cover will develop to soften the visual impact of the cleared areas.

The felling of so many trees will generate an immense amount of slash. The method used to dispose of it on Gregory Bald, dragging it into the woods,

will not be feasible when the entire bald is cleared. Even though only a small fraction of the trees was cut down, we had great difficulty in finding a place to put all the cut trees. Dragging the slash through the woods caused considerable damage to the understory. If fire is used to maintain the balds, the large piles of brush would be a hazard because the blaze would be difficult to control if they caught fire. The visual impact of the brush piles will persist for many years. Therefore, I suggest that at least the branches of the felled trees be burned. Even green branches will burn if one starts a small, compact, hot fire. One might help kill patches of blueberries or other undesirable vegetation by setting these fires on top of them. With the branches cut off, the main trunks would lie flat on the ground and rot quickly if they were not used to build fences. This burning would cause considerable smoke while it was in progress and would temporarily affect local air quality.

The main impact of clearing is the restoration of the 1935 views and general appearance. Seeing spectacular views from distinctive grassy areas and flowering shrub displays would be very pleasant to most visitors. The appearance of the ground where trees and blueberries were cleared away would be unattractive until a few years of management restored a grassy ground cover.

Clearing will have an effect on wildlife in the area. The densely branched hawthorns are favored nesting sites for many birds, and the shrubby areas are an excellent habitat for deer and rabbits. These animals will be displaced until a belt of similar vegetation develops at the edge of the managed zone. If clearing is done in the fall or winter, erosion

may occur, but revegetation of bared ground was so rapid in the course of experiments on Gregory Bald that it seems unlikely that any erosion will occur if the balds are cleared in the spring or early summer.

All woody plants other than conifers that should be removed from the balds will sprout when their tops are killed. Small stumps of species such as yellow birch that do not have tap roots can be prevented from sprouting by chopping the stumps out of the ground. If cheap labor such as YCC is available, this may be worthwile. Other methods of sprout control are more properly considered as maintenance and will be discussed in the next section. Restoration of the original grass-dominated cover will require years of continued disturbance and will also be discussed in the next section.

III. MAINTENANCE

Grassland cannot continue to exist in an area where the natural vegetation is forest without continued disturbance. Therefore regular disturbance of the community in the form of grazing, mowing, or burning will be necessary to prevent the regrowth of woody plants on the cleared balds.

The historical method of maintaining grassy balds in the Smokies was grazing. Thousands of sheep and cattle were grazed on the mountaintops in the summer. The balds themselves were cropped mostly by sheep. Continued over at least 75 years, grazing suppressed regeneration of all woody plants and maintained a herbaceous community dominated by grasses, particularly *Danthonia compressa* (Lindsay 1976).

Grazing will lead to an appearance most like that which existed before the park was established because grazing animals affect vegetation by trampling, grazing selectively, and fertilizing with their dung and urine, thereby altering the species composition of a grassy sward (Duffey *et al.* 1974). According to Park Service policy (U.S.D.I. 1975), "Grazing and raising of livestock is permitted in historic zones where desirable to perpetuate and interpret the historic scene . . . . In historic zones, agricultural activities . . . are permitted where they conform to those that occurred during the historic period and where they do not detract from the principal interpretive purposes." Therefore from a purely historical point of view, grazing would be acceptable.

However, grazing as it would have to be practiced now would require the construction of fences and other structures that were not present in historical times; livestock cannot be permitted to roam all over the mountains as they used to. These structures would be an intrusion on the historic scene and the wilderness value of the surrounding areas. Old photographs of balds show large herds of sheep grazing on the balds; very few other animals were present. Sheep are not intelligent and are easy prey for bears and panthers. They are subject to many diseases and would require constant care to ensure that they did not transmit diseases to the native deer population. Cattle, which were also present on the balds in historic times, require so much water that it would not be feasible to keep them on Gregory or Andrews balds, which have no reliable water supply. Goats and donkeys would be easier to manage, but they are not in keeping with the historical scene since few, if any, of these kinds of animal were

grazed. Livestock could cause considerable erosion. Recovery of patches rooted by wild boar on Gregory Bald was hindered by animals taking dust baths in them.

The costs of grazing would include the cost of building fences, the cost of the animals (60-70 per bald) or the fee for a contractor to bring his animals there, and the salary for a herder to look after the animals. If most trees and shrubs were cut down first, perhaps half as many animals would be sufficient, about 30 or 35 on each bald.

Grazing by goats or sheep would undoubtedly control sprouts effectively, and either these animals or donkeys could maintain an established grassy sward. However, the problems of managing large numbers of livestock in these remote areas surrounded by wilderness, the intrusion on the scenic values that would be caused by fences, and the probable high costs make me reluctant to recommend grazing.

Fire is the most promising technique. Most published literature describes the effects of fire on prairies or coastal plain grasslands, but some general conclusions are applicable to the Great Smoky Mountains area. The Forest Service has burned large areas in the southern Appalachians with good results.

Fire is considered to be a factor in the perpetuation of many grasslands. Even fire-adapted woody species cannot survive in areas that are burned often. Woody plants have difficulty invading established grassland if they are subject to fire (Vogl 1974). Fire can increase the vigor of grasses by removing accumulated litter and encouraging seed production (Dufft et al. 1974).

Fires do not seem to have been used much to maintain balds in the Smokies. The grass left by the grazing sheep on the balds was too short to provide fuel for a fire. The surrounding forests were often burned in the fall, but the balds were not. Since fire was used near the balds if not on them and since the visual impact of a spring fire does not persist long, the deviation from historical methods is probably not important.

In the southern Appalachians controlled burns can be carried out in the fall after the first killing frost or in the spring before the grass starts turning green. In the Smokies these times are October-November and April. Favorable weather is more likely to occur in the fall. Burns are most successful after several days of low humidity. In the fall a period of suitable weather can be recognized as a cold high pressure moving east over the Ohio Valley and becoming stabilized over the Appalachians as a warm high, otherwise known as Indian Summer (Zeedyk 1973). Suitable weather is less predictable in the spring. Most of the Forest Service's spring burns have occurred in May. Fires set in the fall are more effective because the fuel is less compacted. Offsetting the advantages of fall burns is the much quicker regeneration that occurs on areas burned in the spring. Areas burned in the fall are without vegetative cover through the winter and erosion and loss of nutrients are likely. Areas burned in the spring become covered with green growth earlier in the growing season because the blackened ground warms up more quickly.

Fires tend not to burn evenly over a large area, but repeated burns of the same area will tend to even out the effects. The main disadvantage of fire is that it will not select for desirable woody plants such as the azaleas

on Gregory Bald. Any selection will have to be done by hand cutting. Since burns will establish a thick grassy sward that is resistant to invasion by woody plants (Vogl 1974), burning will be necessary only every 2 or 3 years once the sprouts of cut trees and blueberries are under control and the grassy cover well established.

The best method to set the fires would probably be to use methods similar to those used by the Forest Service. Perimeter lines around the area to be burned can be burned in or hand raked and fire set to burn against the wind. Since the areas are small, less than 10 ha including a part of the surrounding forest, it should take no longer than 4 or 5 hours to burn one bald. An eight to ten-man crew would probably be sufficient.

If burning fails to retard sprouts and seedlings, mowing is an alternative in lieu of grazing. Large tractor-drawn mowers could not be transported to either bald, and the steep slopes and rocky ground would make them useless on much of the area of the balds. Duffey et al. (1974) mentions hand-pushed power mowers that ride on a cushion of air. These mowers can be used on rough and steep terrain. A person can now about 1 acre per day using such a machine, so it would take about 15 man-days to mow each bald.

Mowing with scythes would not be much more expensive than using power tools, especially if volunteer labor were used. A person walking half a mile per hour and cutting a swath 2 feet wide would cut about 0.12 acres per hour or nearly an acre per day if he were able to work steadily. I have heard that a really good worker can mow 2 or 3 acres in a day. Therefore, a crew of 10 could mow each bald in about 2 days. Mowing by hand might favor grasses more than mechanical mowing

since most of the grass on the balds has soft stems that bend aside rather than being cut by a scythe. Many forbs and all sprouts will be cut.

Scythes could be carried to the balds by the workers, but power mowers would have to be packed in on horseback. They are also much more expensive to buy and maintain.

Any kind of mowing requires that tree stumps be cut as close to the ground as possible. If mowing is to be used as the main method of maintenance, it will probably be necessary to fell trees with chain saws.

If power machinery must be used, disturbance of visitors by noise could be minimized by using large crews to do all that needs to be done with power tools in 1 or 2 days. If necessary, trails leading to the balds could be closed temporarily. Crews doing follow-up hand labor could then work at leisure with little disturbance of visitors.

SUMMARY

Woody plants started invading Gregory and Andrews balds soon after local people stopped grazing their livestock on them in the summer. The growth of trees and shrubs has greatly changed the appearance of the balds from what it was when Great Smoky Mountains National Park was established. The scenic and historical values of the balds will be lost unless they are restored to their original appearance and managed to maintain that appearance.

Restoring the original appearance will require cutting down trees and shrubs that have grown on the balds and in the surrounding forests since the park was established. Early spring would be the best time. Ample evidence in the form of old maps and photographs exists to guide restoration. Several years of burning or grazing will be required to develop a grassy sward where trees and shrubs have been removed. Sprouts of trees and shrubs will have to be cut by hand several times each growing season or subjected to grazing for several years to be brought under control.

Once the trees are cut down, grassy cover can be restored by grazing, burning, mowing or a combination.

Grazing would require a herd of 60 to 70 goats or sheep on each bald. A sturdy fence would have to be built around the managed area. Animals would cost from $30 to $100 each, depending on age and quality, unless a contractor could be found to graze his animals on the balds. A herder would have to stay up near the bald with the animals all the time they were up there to help protect them from predators and round up stray animals. Animals would require salt, water, and periodic worming. If the Park Service

were to buy the animals, they would have to be kept through the winter. After 5 years or so, fewer animals could be used each year or the same number used only every third or fourth year. Grazing would probably lead to vegetation similar to that existing when the park was established and favor azaleas on Gregory as could no other method besides cutting every other species by hand.

If fire is used to maintain the balds, they should be burned every spring for 5 or 6 years. Sprouts not affected by the fire would have to be cut by hand. After a herbaceous (hopefully grassy) cover has been attained, burning would be necessary only every 2 or 3 years. Burning will be much cheaper than grazing but will not favor azaleas nearly as much except in conjunction with extensive hand cutting of other shrubs. If fire is ineffective in controlling sprouts and seedlings, annual mowing should be used if grazing is not. Combinations of these methods are also possible; burning and mowing are recommended.

Impacts, effectiveness, and costs of suggested techniques are summarized in Table 4.

TABLE 4

COMPARISON OF SUGGESTED MANAGEMENT TECHNIQUE
FOR GRASSY BALDS IN GREAT SMOKY MOUNTAINS NATIONAL PARK

Treatment	Impact	Expenses
I. No management	Disappearance of balds with concomitant loss of views, flowering shrubs, and historic appearance.	None
II. Restoration		
A. Cutting down trees and Shrubs	Restoration of former views and general appearance. Azaleas on Gregory released and made more visible Temporary exposure of bare ground until new herbaceous cover is established Increased runoff Possibility of erosion	About 500 man-hours per bald if mostly hand tools are used. Forest Service estimates cost at $100 per acre with power tools on more accessible sites. Clearing should be done only once, so comparative cost of hand and power tools is not important in the long run
1. Cutting with hand tools	No noise or oil pollution More conspicuous stumps More trampling and damage to understory which can be minimized if care is taken	Higher labor costs if regular Park Service personnel are used. YCC workers can use these tools for all but largest trees Modest investment in axes, hand saws, brush cutter, pruners and scythes.

TABLE 4 (continued)

Treatment	Impact	Expenses
2. Cutting with power tools	Noise and oil pollution Neat, low stumps Less trampling around trees	Time reduction of 25-50% Remote location rendered maintenance difficult; breakdowns more likely as a result.
B. Removing cut trees and shrubs		
1. No removal of slash	Unsightly appearance Slower regeneration of ground cover Fire hazard Sprouts protected from browsing Presence of down and dead wood encourages fires and illegal camping	None
2. Dragging slash into woods	Damage to understory Accumulation of brush in forest around managed area; wall of brush 10 m wide will probably result. Fire hazard Damage to understory can be minimized by carrying rather than dragging	1000 to 4000 man-hours per bald Size and branchiness of large fir trees on and around Andrews Bald might slow down work. Suitable work for YCC Higher labor cost
3. Burning cut trees and shrubs	Some damage to understory, although distance over which branches are dragged would be less. Burned spots on and around bald Quick release of nutrients to soil Deer more likely to browse burned areas May help kill undesirable species	Not tried on large scale Likely to take at least as long as cutting and dragging.

TABLE 4 (continued)

Treatment	Impact	Expenses
C. Sprout Control		
1. No control	All cut trees and shrubs other than conifers will sprout. Resulting thicket of sprouts will look worse than if trees and shrubs had never been cut	None
2. Handcutting	Can control sprouts if continued for several years. Highly selective for desired species (azaleas e.g.)	Up to 300 man-hours per bald each time will probably be necessary two or three times per growing season for 5 or 6 years. May take less time on Andrews Bald because of predominance of conifers. Less time needed to find sprouts if grass is short. Suitable work for YCC.
3. Fire - See Maintenance		
4. Grazing - See Maintenance		

TABLE 4 (continued)

Treatment	Impact	Expenses
III. Maintenance		
A. Grazing	More thorough than hand cutting in controlling sprouts if suitable species (e.g. goats) used Will create vegetation most like original. Selects in favor of azaleas if cattle not used. May adversely affect water quality Will keep grass short Possibility of erosion	Fencing-building good rail fences around managed area. Obtaining livestock herder to look after them and round up strays. Animals may be lost to bears and mountain lions. Supplementary feed and salt. Chasing strayed animals around the mountains. People to assist in driving animals to balds. Rental of truck to carry them to trailhead.
B. Fire	Smoke while burn is in progress Blackened appearance--will be of shorter duration if burned in spring. Possible erosion--less likely if burned in spring. May temporarily increase turbidity of runnoff water. Spring burn alone will not control sprouts of cut trees although it will help keep new woody plants from becoming established. Favors perennial grasses. Will help establish thick grassy sward that will resist further invasion Will not favor azaleas	Eight to ten men for one day for each bald. No major investment in equipment since only normal fire equipment such as drip torch, fire rakes, backpack pumps, is needed.

TABLE 4 (continued)

Treatment	Impact	Expenses
C. Mowing	Will control sprouts if done frequently enough.	All mowing will require that stumps be cut low.
1. Hand tools (scythes)	Will cut sprouts and stiff-stemmed forbs; will not cut most grass stems Said to increase diversity (Duffey *et al.*). Esthetically appealing--no noise and no drastic change in appearance as with fire.	Fifteen to thirty man-days per bald. About $20 each for scythes (aluminum snaths recommended).
2. Power mowers	Similar to hand mowing in effect on vegetation but less likely to favor grass. Noise and gasoline fumes.	Fifteen man-days per bald. Large investment in equipment. Equipment will have to be packed in on horseback. Equipment maintenance may be difficult.

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